Prepared in cooperation with the
WYOMING STATE ENGINEER

STREAMFLOW CHARACTERISTICS

The natural flows of streams in the Bighorn Basin differ greatly due to a wide range in the meteorologic, topographic, and geologic conditions of the basin. Wahl (1970) reported streamflow in the mountainous part of the area to be related significantly to drainage area, areas of lakes and ponds, mean basin altitude, mean annual precipitation, and latitude. Most of the Bighorn Basin is semiarid; however, large amounts of precipitation occur in the mountains that border the east, south, and west sides of the basin. Streams whose headwaters are in the mountains, therefore, have greater yields per square mile of drainage than streams whose headwaters are not in mountainous areas. The flows of many of the streams in the basin may be studied by referring to the table of streamflow characteristics. The station locations and the average discharge per square mile are shown on the map and give an indication of the geographic variation of basin yields. The flow characteristics of some streams are affected by reservoirs and diversions which are indicated in the table.

The maximum instantaneous discharge that has occurred at each station during its period of record is shown in the table. The magnitude and frequency of floods at either gaged or ungaged sites can be estimated by using the precedures described by Patterson (1966).

Most of the runoff in the basin is from snowmelt in the mountains. The seasonal runoff patterns of a perennial stream are shown by a graph of mean monthly flow. The maximum and minimum flows show the observed range of values, which is primarily due to the year-to-year variation in precipitation. Ephemeral streams flow only in response to snowmelt or rainfall, and the periods of runoff are usually separated by long periods of no flow.

The predominant use of surface water in the basin is for irrigation. Shell Creek is typical of most of the mountain streams in that in its lower reaches streamflow is used for irrigation. The amount of water historically used from Shell Creek for irrigation on bordering lands is shown on the graph of mean monthly flow. The irrigation data were obtained from records of the Wyoming State Engineer with the aid of Kenneth Bower, Superintendent of Water Division No. 3. Most of the flow past the gage is used for irrigation during the late summer months. Because some irrigation water returns to the stream, reuse of this water is possible by downstream water users. This makes it possible for irrigation use to exceed the mean gaged flow, as happens on Shell Creek during August.

Ten duration curves are presented for streams in the basin. These curves show the percentage of time daily mean discharges were equaled or exceeded during a given period without regard to chronological sequence.

The shape of a stream's flow-duration curve is determined by characteristics of the drainage basin. The high flows are governed by climate, physiography, and plant cover; whereas, the low flows are controlled largely by the geology of the basin. For example, Fifteen Mile Creek has no base flow because it is incised in relatively impermeable formations. The flow is from direct runoff (curve F). This stream flows less than 30 percent of the time. Most of the other curves are for streams where the high flow comes largely from snowmelt in the mountains. This produces a curve with a flat slope at the upper end. The slope of the lower end of a curve shows the effect of ground-water storage. Although South Fork Owl Creek (curve E) has a mountainous drainage basin, the lower end of its curve has a steep slope because there is a large amount of seepage loss in the lower reaches of the stream.

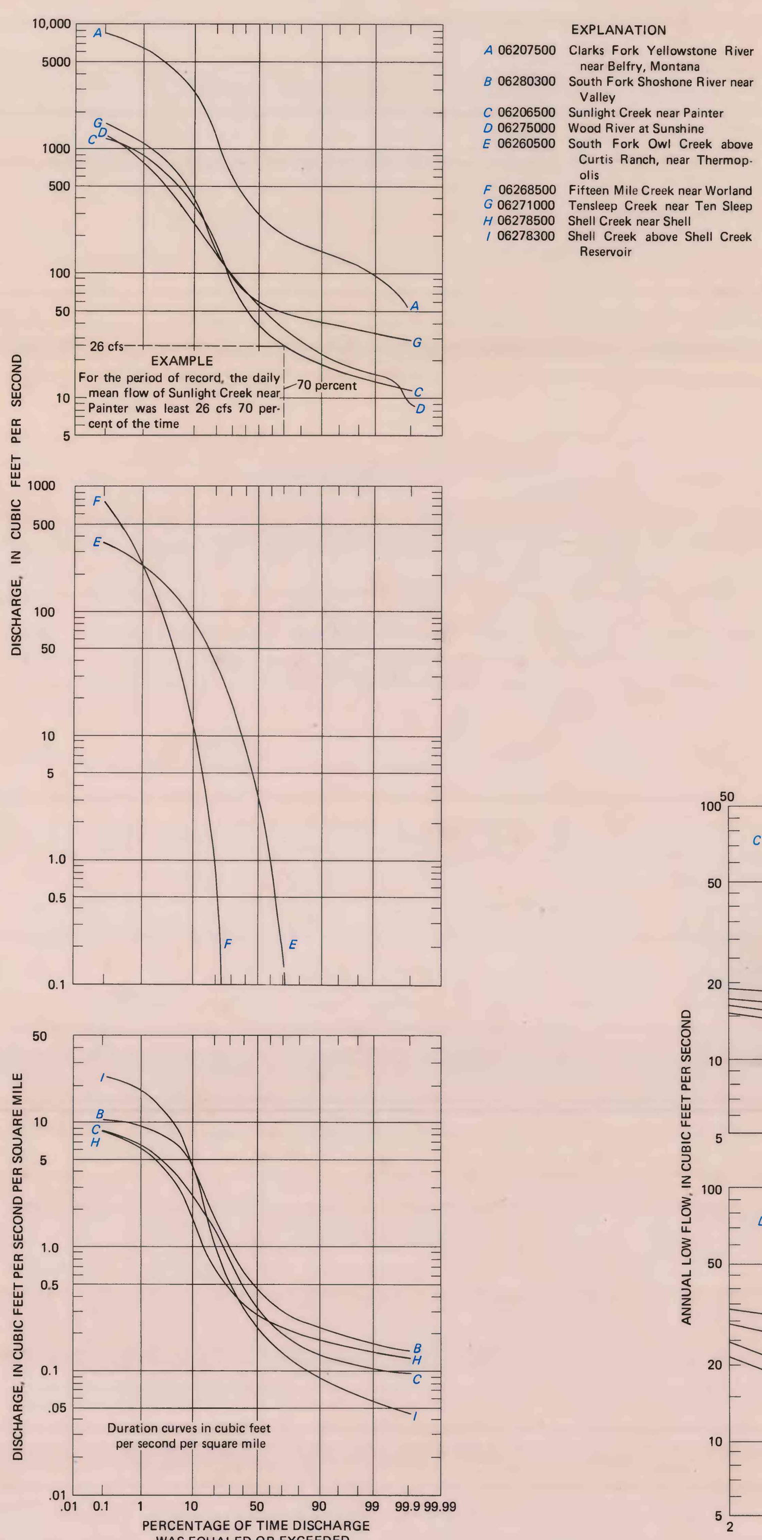
Four duration curves for streams with mountainous drainage basins are shown in a graph with discharge given in cubic feet per second per square mile. These curves may be used to study and compare drainage basin characteristics, particularly the effect of different geologic conditions on low flows. For example, during low flows, the yield per square mile of streamflow of Shell Creek near Shell (curve H) is higher than that of Shell Creek above Shell Creek Reservoir (curve I). The increase is attributed to ground-water release from glacial deposits, which lie between the sites.

Low-flow characteristics are presented in the table by showing the range of annual minimum daily discharge, and by the annual minimum 7-day mean flows having recurrence intervals of 2, 10, and 20 years. In addition to the tabular data, low-flow frequency curves are shown for four stations. These curves show the magnitude and frequency of average annual minimum flow for specified periods of consecutive days. The climatic year, which begins April 1, was used to present the low-flow data because the flows in mountain streams generally have a recession that begins in the summer months and continues through the winter months. If the water year is used, a single low-flow period might be reported as two separate events.

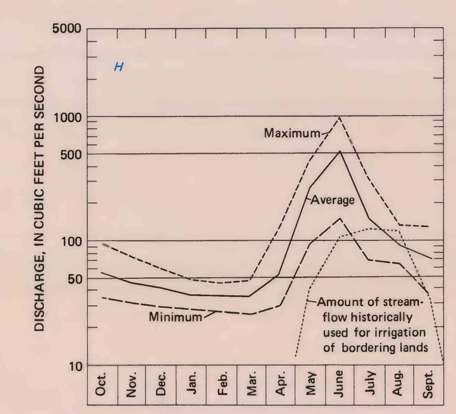
Streamflow characteristics at selected gaging stations[1]

Station No.	Station name	Drainage area (sq mi)	Records available (years)	Annual mean discharge (cfs): Average	Annual mean discharge (cfs): Range	Annual mean discharge (cfs): Exceeded 90 percent of years	Range of annual minimum daily discharge (cfs)	7-day low flows (cfs), Recurrence interval: 2-year	10-year	20-year	Maximum instantaneous discharge (cfs)	Factors affecting natural flow: Acres irrigated by upstream diversions	Remarks
06206500	Sunlight Creek near Painter	135	1929–32, 1945–	123	89.3 – 165	92	10 – 18	16	13	12	2,110	900	
06207500	Clarks Fork Yellowstone River near Belfry.	1,154	1921–	932	648 –1,460	722	33 –191	145	83	66	10,900	11,100	
06259000	Wind River below Boysen Reservoir.	7,701	1951–	1,350	687 –1,948	---	4.7 –889	---	---	---	13,500	196,000	Regulated by Boysen Reservoir since 1951 (capacity, 829,000 ac-ft).
06259500	Bighorn River at Thermopolis	8,020	1912–51	1,857	676 –3,213	1,100	51 –600	43	29	26	29,800	---	Do.
06260000	South Fork Owl Creek near Anchor.	87	1940–41, 1959–69	35.5	12.6 – 62.0	16	.10– 5.0	---	---	---	1,940	0	
06260200	Middle Fork Owl Creek above Anchor Reservoir.	33.6	1959–65	.51	.002– 1.67	---	0 – 0	---	---	---	700	0	
06260400	South Fork Owl Creek below Anchor Reservoir.	133	1959–	20.3	12.6 – 30.1	---	0 – .10	---	---	---	373	0	Regulation by Anchor Reservoir since 1960 (capacity, 17,412 ac-ft).
06260500	South Fork Owl Creek above Curtis Ranch, near Thermopolis.	144	1943–59	26.5	9.78 – 40.3	15	0 – 0	0	0	0	1,520	400	
06262000	North Fork Owl Creek near Anchor.	54.8	1941–62	13.4	4.60 – 31.2	4.7	0 – 1.0	.20	0	0	3,200	---	One small diversion for irrigation.
06262400	North Fork Owl Creek above Basin Ranch near Anchor.	61	1962–	14.8	0 – 2.0	---	0 – 2.0	---	---	---	1,370	820	
06264000	Owl Creek near Thermopolis	478	1910–17, 1931–32, 1938–69	27.4	2.91 – 81.0	5.4	0 – 5.0	.90	0	0	7,030	14,000	Regulation by Anchor Reservoir since 1960.
06264500	Owl Creek near Lucerne	505	1932–33, 1938–53	22.9	1.05 – 61.5	2.3	0 – 1.0	---	---	---	928	18,000	
06265000	Kirby Creek near Lucerne	240	1941–45	---	10.8 – 21.5	---	0 – .10	---	---	---	980	100	
06265500	Cottonwood Creek at Winchester.	432	1941–45	---	10.4 – 41.9	---	0 – 0	---	---	---	4,120	2,900	
06265800	Gooseberry Creek at Dickie	95.0	1957–	12.0	3.58 – 21.3	3.6	0 – 1.8	.40	0	0	1,130	0	
06266000	Gooseberry Creek near Grass Creek.	142	1945–57	13.8	2.04 – 29.7	2.7	0 – 5.8	0	0	0	593	800	
06267000	Gooseberry Creek at Neiber	361	1941–44, 1945–53	12.5	.45 – 31.4	.55	0 – 0	---	---	---	1,650	3,000	
06268500	Fifteen Mile Creek near Worland.	518	1951–	10.8	3.52 – 17.0	3.6	0 – 0	---	---	---	3,300	0	Extensive spreader systems on some tributaries.
06270000	Nowood River near Ten Sleep	803	1938–43, 1950–55	98.9	58.7 – 175	60	.70– 17	---	---	---	3,330	4,000	
06270500	Canyon Creek near Ten Sleep	66.3	1939–44	32.1	25.1 – 36.9	---	16 – 19	---	---	---	248	[illegible]	
06271000	Tensleep Creek near Ten Sleep	247	1910–12, 1914–24, 1943–	146	85.2 – 226	100	26 – 55	38	31	30	2,890	350	
06271500	Paintrock Creek below Lake Solitude.	16.0	1946–53	33.3	28.8 – 35.5	---	---	---	---	---	341	0	
06272500	Paintrock Creek near Hyattville	164	1920–26, 1941–53	146	110 – 234	114	10 – 19	16	13	12	8,200	12	
06273000	Medicine Lodge Creek near Hyattville.	86.8	1942–	34.6	22.7 – 47.1	23	4.1 – 12	8.8	7.7	7.4	1,160	40	
06273500	Paintrock Creek near Bonanza	398	1910–13, 1915–22	155	89.9 – 197	91	.70– 18	---	---	---	3,390	7,000	
06274500	Greybull River near Pitchfork	282	1946–49, 1951–	178	97.3 – 281	100	8.0 – 23	18	11	9.4	8,610	1,850	
06275000	Wood River at Sunshine	194	1945–	115	47.3 – 194	56	2.8 – 33	25	9.1	5.8	5,080	3,200	
06275500	Wood River near Meeteetse	218	1910–12, 1914–16, 1929–49	126	49.6 – 228	67	9.0 – 38	---	---	---	2,150	6,800	
06276500	Greybull River at Meeteetse	681	1897, 1903, 1920–	347	130 – 566	174	16 – 73	49	31	26	13,600	11,000+	Some regulation by Sunshine Reservoir since 1939 (capacity, 53,000 ac-ft).
06277500	Greybull River near Basin	1,115	1930–	183	42.0 – 418	54	0 – 20	10	5.5	0	19,400	63,300	Do.
06278000	Dry Creek at Greybull	433	1951–53, 1955–60	23.2	12.2 – 35.0	---	0 – 3.0	---	---	---	998	800	Part of flow is return flow from lands irrigated by Farmers Canal diverting water from Greybull River.
06278300	Shell Creek above Shell Creek Reservoir.	23.1	1956–	37.0	18.6 – 50.2	20	.60– 2.0	1.7	1.1	1.0	1,870	0	
06278500	Shell Creek near Shell	145	1940–	118	77.3 – 160	80	18 – 33	31	23	21	3,020	80	Some regulation by Adelaide Lake since 1915 (capacity, 3,147 ac-ft) and Shell Reservoir since 1957 (capacity, 1,949 ac-ft).
06279000	Shell Creek at Shell	256	1914–24	142	98.5 – 187	102	---	---	---	---	1,910	4,000	Do.
06279500	Bighorn River at Kane	15,765	1928–51,	2,398	1,072 –3,524	1,150	179 –770	490	220	200	25,200	376,000	Regulation by Boysen Reservoir since 1951.
			1951–	2,092	923 –3,380	1,140	295 –852	---	---	---	25,000		
06280000	North Fork Shoshone River near Wapiti.	800	1921–26	845	715 –1,230	---	100 –145	---	---	---	9,250	1,800	
06280300	South Fork Shoshone River near Valley.	297	1956–58, 1959–	422	288 – 583	298	41 – 74	56	42	39	6,610	450	
06281000	South Fork Shoshone River above Buffalo Bill Reservoir.	674	1903, 1905–07, 1921–26	489	346 – 704	---	9.0 – 50	---	---	---	5,300	11,000	
06282000	Shoshone River below Buffalo Bill Reservoir.	1,583	1921–42,	1,256	911 –1,870	---	14 –369	---	---	---	18,700	18,200	Regulated by Buffalo Bill Reservoir (capacity, 421,300 ac-ft), major diversion to Heart Mountain Canal began in 1943.
			1942–	1,146	616 –1,764	---	59 –555	---	---	---	11,900	37,900	
06283000	Shoshone River at Corbett Dam.	1,740	1908, 1910–25	1,450	845 –1,960	---	134 –515	---	---	---	18,700	---	Do.
06284400	Shoshone River near Garland	2,036	1958–	614	197 –1,066	---	5.0 –125	---	---	---	13,300	143,000	Do.
06285000	Shoshone River at Byron	2,345	1929–66	917	422 –1,652	---	38 –486	---	---	---	16,000	143,000	Do.
06285100	Shoshone River near Lovell	2,350	1966–	---	798 –1,265	---	199 –320	---	---	---	13,400	143,000	Do.
06285500	Sage Creek near Lovell	381	1951–60	106	92.5 – 123	---	10 – 15	---	---	---	1,290	3,500	Flow is mostly return flow from land irrigated by canals diverting water from Shoshone River.
06286200	Shoshone River at Kane	2,989	1957–68	1,141	606 –1,612	---	120 –679	---	---	---	13,200	148,000	Regulated by Buffalo Bill Reservoir.
06286260	Crooked Creek near Lovell	119	1964–67	---	7.95 – 10.3	---	0.17– 0.69	---	---	---	1,460	870	
06286270	Porcupine Creek near Lovell	135	1964–67	---	35.7 – 57.8	---	2.3 – 3.0	---	---	---	1,000	330	

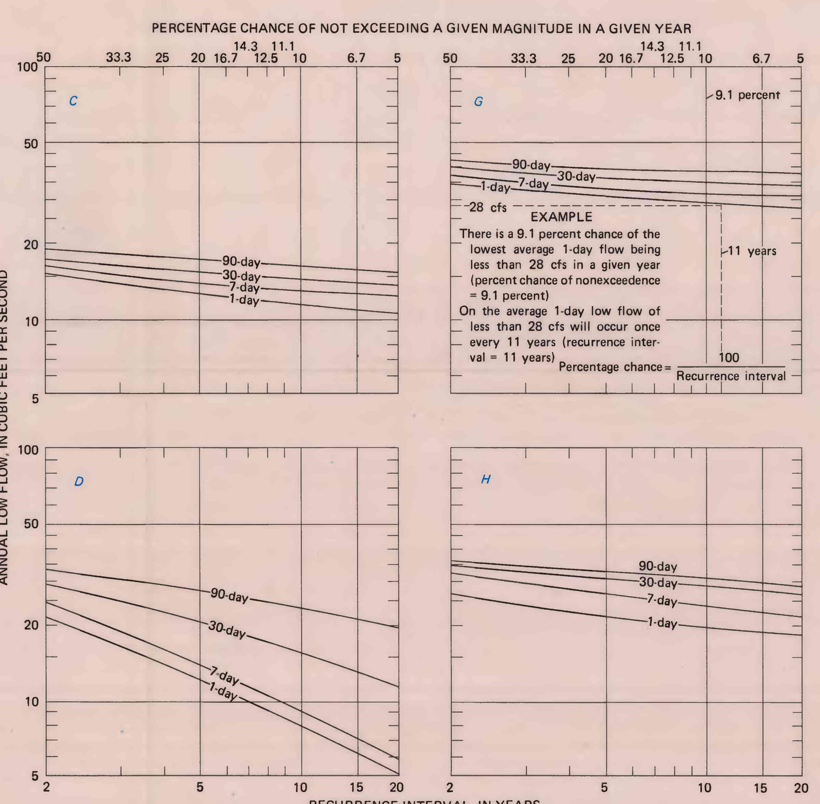
[1] Figures are omitted when an insufficient amount of record has been obtained to produce accurate figures.



DURATION CURVES OF DAILY FLOWS FOR SELECTED STATIONS

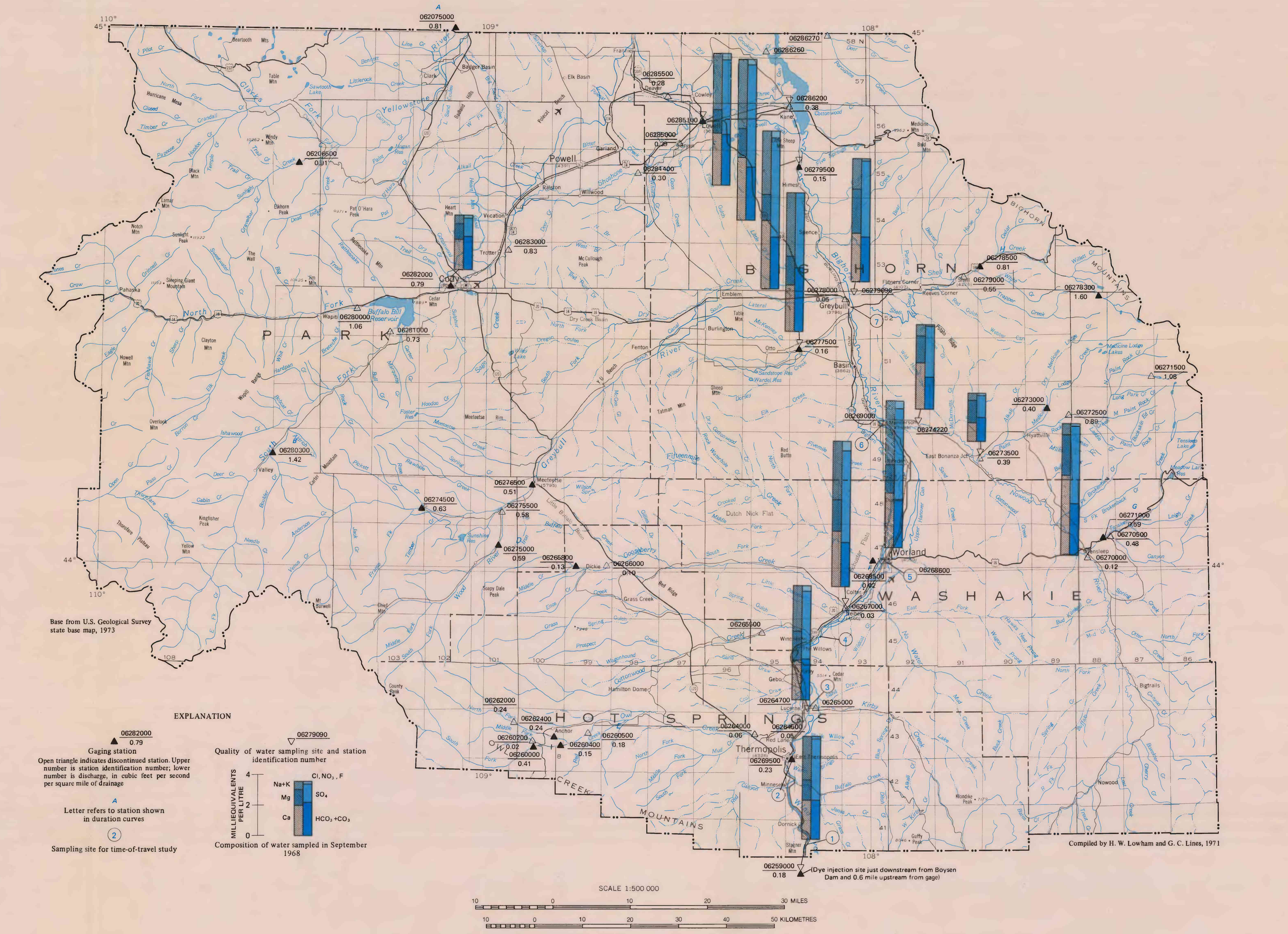


MEAN MONTHLY FLOWS



LOW FLOW FREQUENCY CURVES

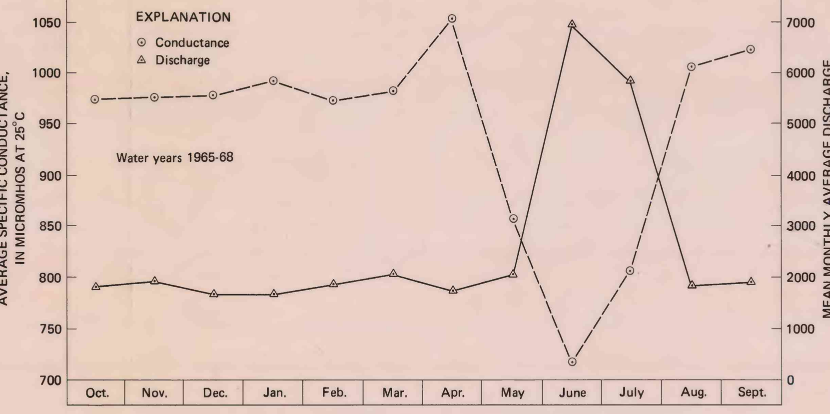
LOCATION OF GAGING STATIONS AND WATER SAMPLING SITES



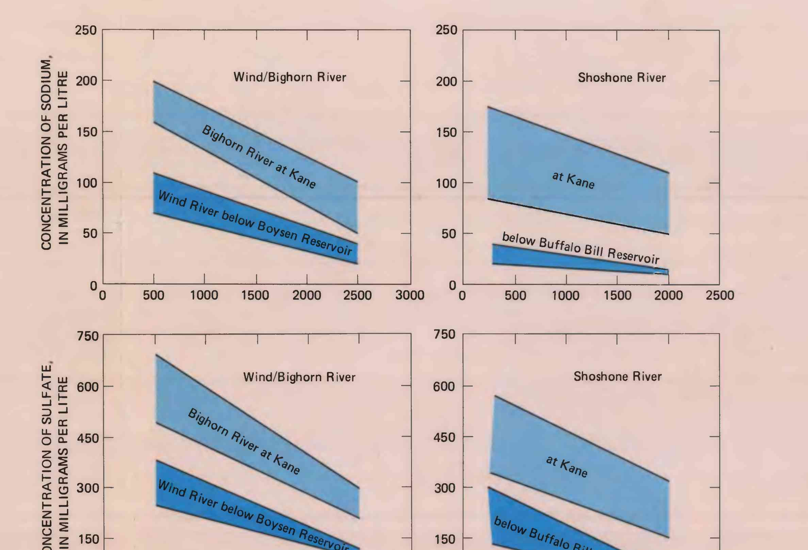
QUALITY OF SURFACE WATER

The chemical quality of surface water differs considerably throughout the Bighorn Basin as indicated by the bar diagrams shown on the map. Water from the upper reaches of streams that head in the mountains is a calcium bicarbonate or calcium magnesium bicarbonate type and is low in dissolved solids. (See Paintrock Creek near mouth, below Hyattville, 06273500.) The water in these streams is derived almost entirely from snowmelt and rainfall, and the chemical quality is relatively constant throughout the year. Calcium sulfate type water in the Nowood River near Ten Sleep (06270000) is attributed to highly soluble gypsum in the rocks of the drainage basin. Water from the Wind/Bighorn River and the lower reaches of the Shoshone and Greybull Rivers is a sodium sulfate or sodium calcium sulfate type, and the concentration of dissolved solids is more variable. The relationship between discharge and the specific conductance is shown for the Bighorn River at Kane. When the discharge of the river is large, most of the water is derived from snowmelt and rainfall and the water has a low specific conductance (an indication of dissolved solids). When the discharge is small, a large part of the water is derived from return flow from irrigation, springs, and oilfields and the specific conductance of the water is high.

Probably the most significant factor affecting the chemical quality of surface water in the basin is the change in quality caused by return flow of irrigation water. Irrigation water in excess of that transpired by plants, or evaporated, percolates down through the soil and a large part of this water is returned to streams. As the water moves through the soil, calcium sulfate and sodium sulfate in the soil may go into solution and, in addition, some calcium already in solution is exchanged for sodium. Thus, the irrigation water returned to streams is usually a sodium sulfate type. Irrigation is practiced along all of the larger streams in the basin and most of the surface water in the area undergoes a change in chemical quality. In the lower reaches of a stream where the return irrigation water is a significant part of the stream discharge, the water is a sodium sulfate or sodium calcium sulfate type. The relationship between the discharge and the concentration of sodium and sulfate, and the downstream increase in these concentrations, is shown for the Wind/Bighorn and Shoshone Rivers in water years 1965–68.



CONDUCTANCE AND DISCHARGE OF WATER, BIGHORN RIVER AT KANE



DISCHARGE AND RANGE IN CONCENTRATION OF SULFATE AND SODIUM IN THE WIND/BIGHORN AND SHOSHONE RIVERS

SUSPENDED SEDIMENT

The sediment transported by the Bighorn River is derived mainly from its tributaries. Some of the tributaries pass through easily erodible material and are actively downcutting and eroding headward. Very little of the sediment is derived from erosion of the banks and flood plain along the main stem because the surficial deposits, which consist of coarse material from the mountains, are relatively resistant to erosion.

Between Thermopolis and Worland, Cottonwood Creek, Gooseberry Creek, Nowater Creek, Fifteen Mile Creek, and the lower end of Kirby Creek carry large sediment loads in response to heavy rainstorms. Owl Creek contributes much sediment due to bank erosion during high flows. Nowater Creek, which is one of the larger tributaries to the Bighorn River, also contributes considerable sediment from bank erosion, particularly during high flows.

Perennial streams that head in the mountains, such as Tensleep Creek, Paintrock Creek, and Shell Creek, are relatively clear throughout the year.

The Greybull River is a source of considerable sediment, particularly in its lower reach. This sediment is contributed principally by bank erosion and erosion of waterways draining irrigated land.

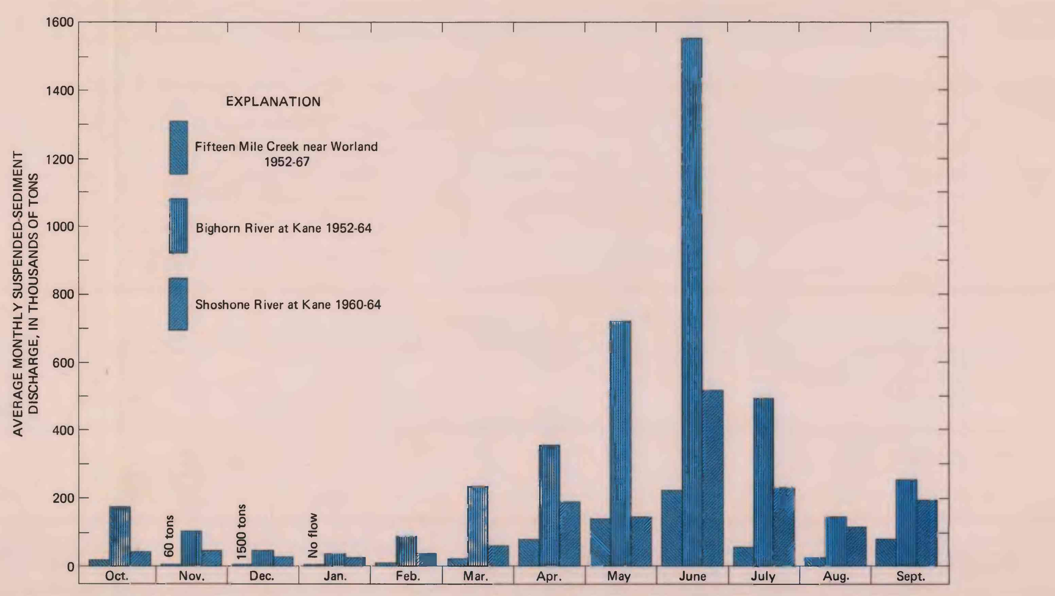
Dry Creek, which is intermittent in the upper reach, gains appreciable flow in its lower reach from return flow from irrigation on Emblem Bench. This flow causes considerable bank erosion along the stream channel.

The Shoshone River in the reach below Buffalo Bill Reservoir carries a considerable sediment load because of bank erosion. Irrigation water from the Heart Mountain irrigation project is returned to the Shoshone River through Alkali, Sage, and Dry Creeks. These creeks provide an additional sediment load to the Shoshone River.

Sediment in Clarks Fork Yellowstone River is derived mainly from tributaries rather than from erosion along the main stem (Lowham, 1969).

Bar diagrams show the average monthly suspended-sediment discharge in thousands of tons for three stations where daily suspended-sediment records are available. The seasonal variation of sediment discharge would probably apply to most streams in the basin. The amount of sediment discharged from Fifteen Mile Creek, an ephemeral stream, is low compared to that from the Shoshone River; however, Fifteen Mile Creek contributes the highest sediment load per acre-foot of runoff.

The table shows maximum daily suspended-sediment loads at stations where daily records have been computed. The period of record before the closure of Boysen Dam is not included because of the effect of the reservoir on the volume of sediment.



AVERAGE MONTHLY SEDIMENT DISCHARGE

Maximum daily suspended-sediment load for period of record since closure of Boysen Dam

Station number	Station	Period of record (water years)	Date of maximum	Daily discharge for day of maximum (cfs)	Maximum daily load: Tons	Maximum daily load: Tons per acre-foot of runoff
06259500	Bighorn River at Thermopolis	1952–	10– 5 –51	2,030	32,600	8
06267000	Gooseberry Creek at Neiber (formerly published as "at Pulliam")	1952–53	5–22–52	330	48,400	74
06268500	Fifteen Mile Creek near Worland	1952–67	5–22–52	1,980	418,000	106
06268600	Bighorn River at Worland	1965–67	6–16–67	9,980	700,000	35
06269000	Bighorn River near Manderson	1952–53, 1956	5–22–52	4,610	614,000	67
06276500	Greybull River at Meeteetse	1955–56	7–24–55	804	45,800	29
06278000	Dry Creek at Greybull	1952–53	5–22–52	345	39,100	57
06279500	Bighorn River at Kane	1952–64	5–23–52	6,990	600,000	43
06285500	Sage Creek near Lovell	1951–53	7–11–51	398	14,800	19
06286200	Shoshone River at Kane	1960–64	9–19–61	7,930	524,000	33

TIME OF TRAVEL ON WIND/BIGHORN RIVER

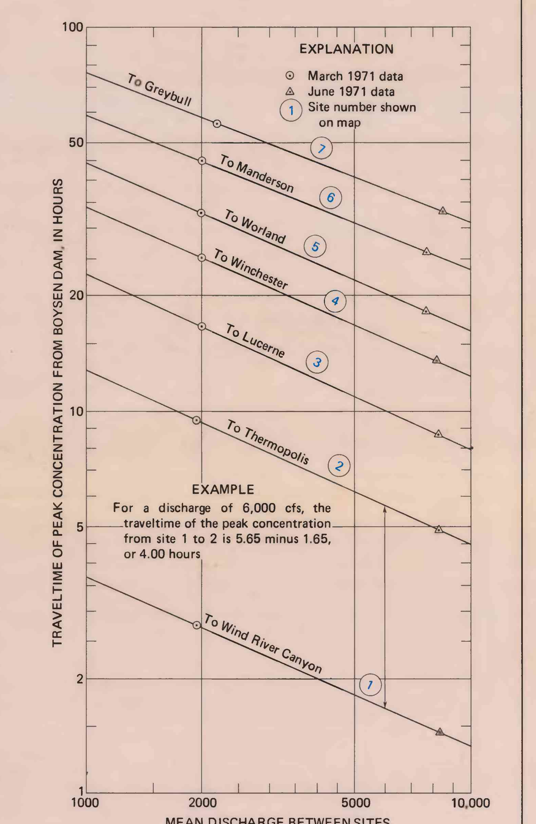
Time-of-travel characteristics can be important knowledge in the event of an accidental spill of a contaminant into a stream. Knowing the velocity and expected dispersion pattern of the contaminant, water users downstream from the spill can take necessary protective measures.

The Wind/Bighorn River was selected for a time-of-travel study because (1) it is a major river in the Bighorn Basin, (2) it has a large number of municipal, industrial, and agricultural water users, and (3) the potential for an accidental spill of contaminants exists because a highway and railroad border the river for about 14 miles in Wind River Canyon. In order to define traveltime of the river throughout a useful range of flows, one study was made during March 1971 at a low discharge and a second study was made during June 1971 at a discharge that has been exceeded only a few times since completion of Boysen Dam in 1951.

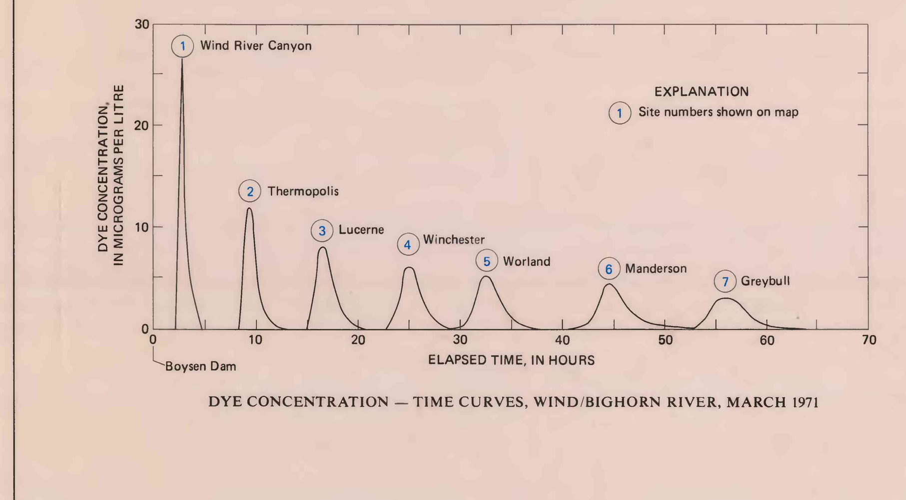
A fluorescent dye, Rhodamine WT, was used to make the time-of-travel measurements. The dye was injected as a single slug into the river just below Boysen Dam, and the movement of the dye cloud was traced by sampling the river water at seven downstream sites. The locations of these sites are shown on the map.

Data from the water samples were used to plot curves, which show the variation in dye concentration as the dye cloud passed each site. An example of these curves is shown for the March 1971 measurement. The curves show how the dye became dispersed longitudinally along the stream. The dye cloud took longer to pass each succeeding site and its peak concentration decreased with time.

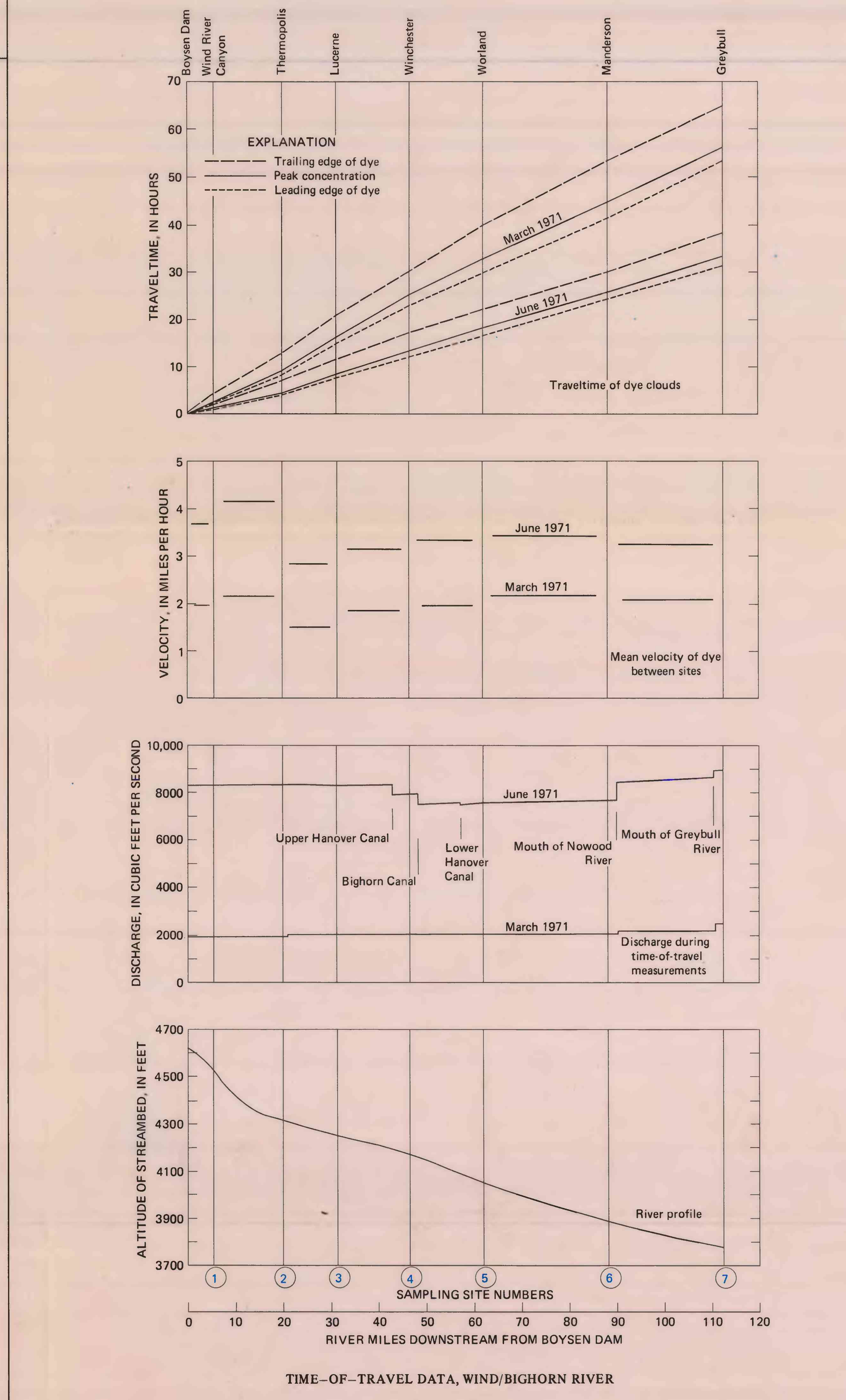
The river profile, discharge during the measurements, and mean velocity and traveltime of the dye clouds are shown in graphs with the distance given as river miles downstream from Boysen Dam. A means of predicting the traveltime between any two locations on the river is shown in the curves relating traveltime to discharge. The traveltime between any two locations may be determined from the graph by obtaining the average discharge of the river between the two locations. Stream-gaging station 06259000, Wind River below Boysen Reservoir, is the principal index to discharge in the study reach. Discharge information of the Wind/Bighorn River can be obtained from Geological Survey offices in Worland or Cheyenne.



TRAVELTIME VERSUS DISCHARGE, WIND/BIGHORN RIVER



DYE CONCENTRATION—TIME CURVES, WIND/BIGHORN RIVER, MARCH 1971



TIME-OF-TRAVEL DATA, WIND/BIGHORN RIVER

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Surface Water

WATER RESOURCES OF THE BIGHORN BASIN, NORTHWESTERN WYOMING

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1976